Strataform Plume Study

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LONG-TERM GOAL

The overall goal of the ONR STRATAFORM program is to advance our understanding of the formation of stratigraphic sequences on continental shelves and slopes.

OBJECTIVES

The primary objectives of this project are to conduct observations to determine the mechanisms of cross-shore sediment transport on the Eel river shelf and to relate the transport to the source of sediments in the Eel river plume.

APPROACH

Accomplishing these objectives involves pursuing long-period monitoring programs focusing on river discharge plumes and sediment transport in the bottom boundary layer. For the past three years, such measurements have been made on the continental slope region in Northern California off the Eel River. Experimental data to date have produced an interesting debate as to the pathways the river discharge sediment takes to its ultimate destination (the latter of which is also not well known). One important part of this overall question is: how does the large amount of sediment that has been observed at midshelf by Wheatcroft et al. get there? Originally, the conjecture was that direct deposition by fallout from the plume was responsible. However, it was soon observed that the river plume "hugs the shore" more than was originally expected. Moreover, bottom tripod data has shown that a large amount of sediment, initially deposited by the plume inshore of the midshelf patch, was later transported seawards towards the patch in the bottom boundary layer [*Cacchione et al.*, 1998]. Our acoustic backscatter sensor (ABS) has revealed that during these periods of offshore transport of fine sediment from the inner shelf to the deposition area, high concentration layers can form near the seabed. These layers have properties consistent with fluid mud, which may be important in determining the stratigraphic signature of the resulting deposit. It became increasingly obvious as the STRATAFORM program progressed that simultaneous measurements of sediment transport in the discharge plume and in the bottom boundary layer needed to be made if one were to understand sediment transport pathways.

WORK COMPLETED

To address that need, the P.I.'s in this project, in close collaboration with W.R. Geyer of WHOI (who's primary interest is in modeling the river discharge plume), deployed three instrumented tripods and three

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instrumented moorings from November 1997 to May 1998 along the cross-shore "K-line" that cuts across the Eel river plume close to the river mouth. The instrumentation upon the tripods and moorings was specifically targeted at measuring: the current field (via the ADCP's and S4 current meters), the temperature and salinity fields (via the T-pods and SeaCAT's), and the sediment concentration field (via the OBS and ABS sensors.) In addition, LISST laser diffraction particle sizers were attached to both the moorings and one tripod, and a sector scanning sonar was attached to the K40 tripod to measure the bottom microtopography evolution.

After expending considerable effort in the recovery phase due to partial burial of the instruments, we retrieved the moorings in spring 1998, and also recovered the K20 and K60 tripods. Efforts with ROV's and divers to recover the K40 tripod, which was apparently hit by a dragger as well as largely buried, proved unsuccessful, and only one LISST sensor was recovered from that platform. The instruments on the moorings worked quite well, with very few failures, so that we have a high quality "plume data set" in hand. As to the tripods, the K60 tripod brought back the highest quality data set, which included good ABS, EMCM, and OBS sensor data. At K20, the ADCP instrument worked well, giving interesting data even past the time the transducer head was buried.

RESULTS

Preliminary analysis of the data from the mooring and tripod array has revealed an interesting view of cross shelf transport processes on the Eel River Shelf. Thanks to the strong El Nino event, the Eel River produced four major flood events (Mean Hourly discharge measured at Scotia Station of greater than 4,000 cubic meters per second), and an extended period with significant wave heights in excess of 6 m. As expected from the rapid response surveys, the plume is confined to the near shore region. This can be seen in the mooring data by high OBS readings at 0.5 and 4.5 m depth at the K-20 site and low OBS readings at the K-40 and K-60 moorings during periods of high river discharge (Figure 1).

Underneath the plume an ADCP at K20 provided excellent data on the vertical structure of mean currents. However, from a sediment transport point view, the most interest data point from the K-20 ADCP is that it was buried on Jan. 20 during one of the largest wave events of the deployment which occurred just after a period of sustained high river discharge. Acoustic attenuation estimates reveal that 10-30 cm of sediment was deposited on top of the transducer located 50 cm above the tripod feet for a total deposit of 60-80 cm of sediment. This is one of the few data points available on the amount sediment that is deposited on the inner shelf immediately after a period of river high discharge.

On the same date at the K-60 site, ABS data reveals a fluid mud layer of 15 cm thickness that deposits 12 cm of sediment during it's passage (Figure 2). EMCM boundary layer velocity profiles reveal that velocities are faster in the offshore direction 40 cm from the bed than those 1 and 2 m from the bed during this period. This "upside down" boundary layer velocity profile is indicative of a gravity forced offshore flow of the fluid mud with velocities of 40-50 cm/s. First order estimates of cross shelf transport with the K-60 ABS/EMCM indicate that the fluid mud mode of transport is the dominant cross-shelf transport mechanism during periods of high river discharge. Analysis planned for 1999 and 2000 will further examine this data to understand the dynamics of this type of transport mechanism.

IMPACT/APPLICATIONS

The principle impact of this work is to reveal, through observations, the dominant cross shelf transport mechanism. Preliminary analysis of the observations show the fluid mud flows pay a dominant role during periods of high sediment supply, while during periods of low supply, suspended transport plays a more significant role. The observations of the plume will also be used for validating and forcing models of the Eel River plume.

TRANSITIONS

The data collected during the 1998 plume study will be shared with other STRATAFORM investigators. In particular, the observations will provide necessary guidance for the modeling efforts of other investigators.

RELATED PROJECTS

The STATAFORM project provides a unique opportunity to study sediment dynamics in an environment that is dominated by fine sediment during periods of high river discharge. This project provides a sharp contrast to our work in other environments, such as LEO-15 with medium-to-coarse grained sand [*Traykovski et al.*, 1998]. Yet, in both environments it has become apparent that adequately observing sediment concentration and velocity (to calculate transport) in the 10 cm nearest the seafloor is crucial to understanding the dominant mechanisms of sediment transport.

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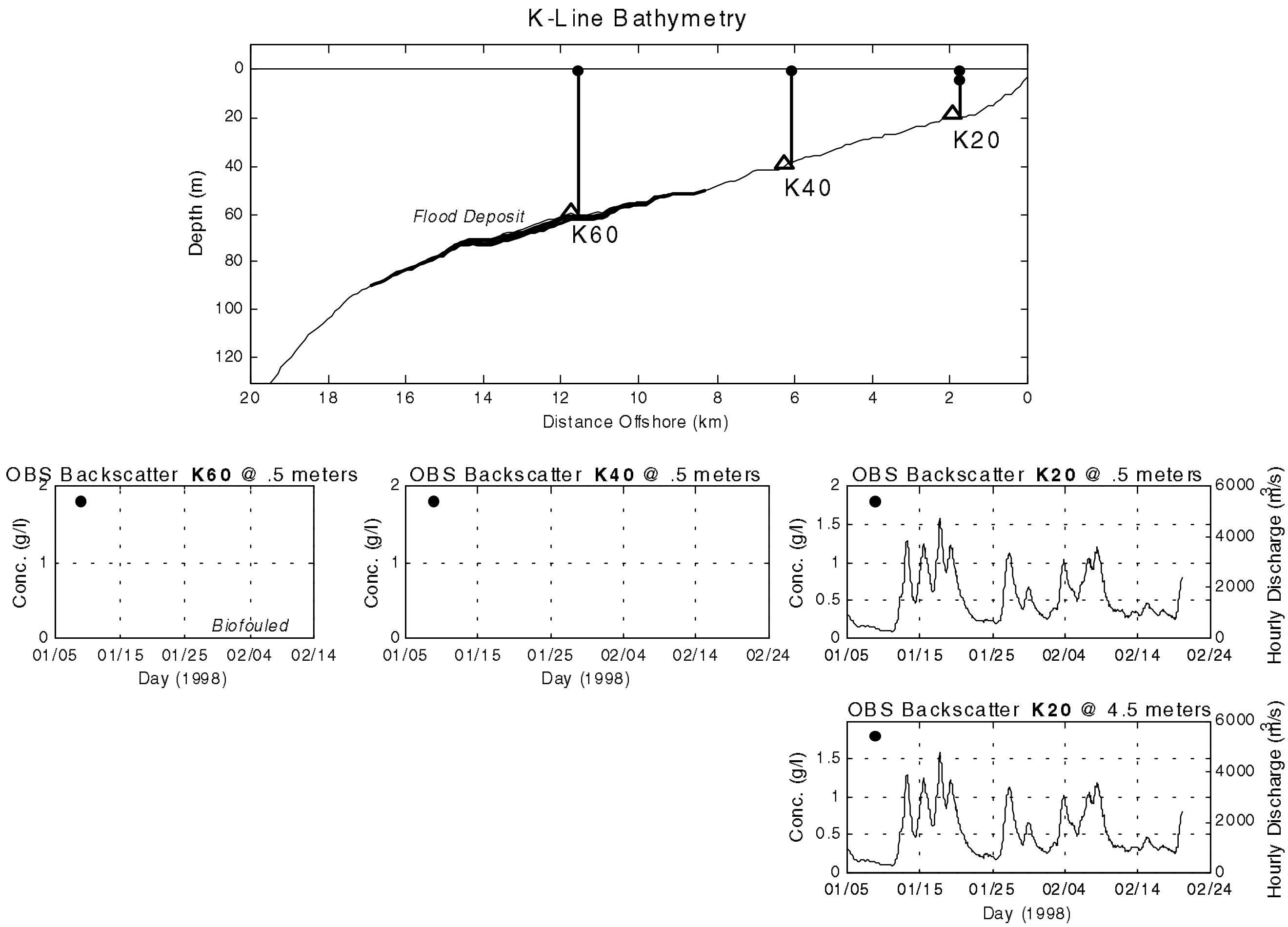

Figure 1. (Top) SRATAFORM K-line bathymetry. (Bottom) OBS time series from K-20, 40 and 60 showing that the plume is confined to the nearshore region and is well correlated to periods of high river discharge.

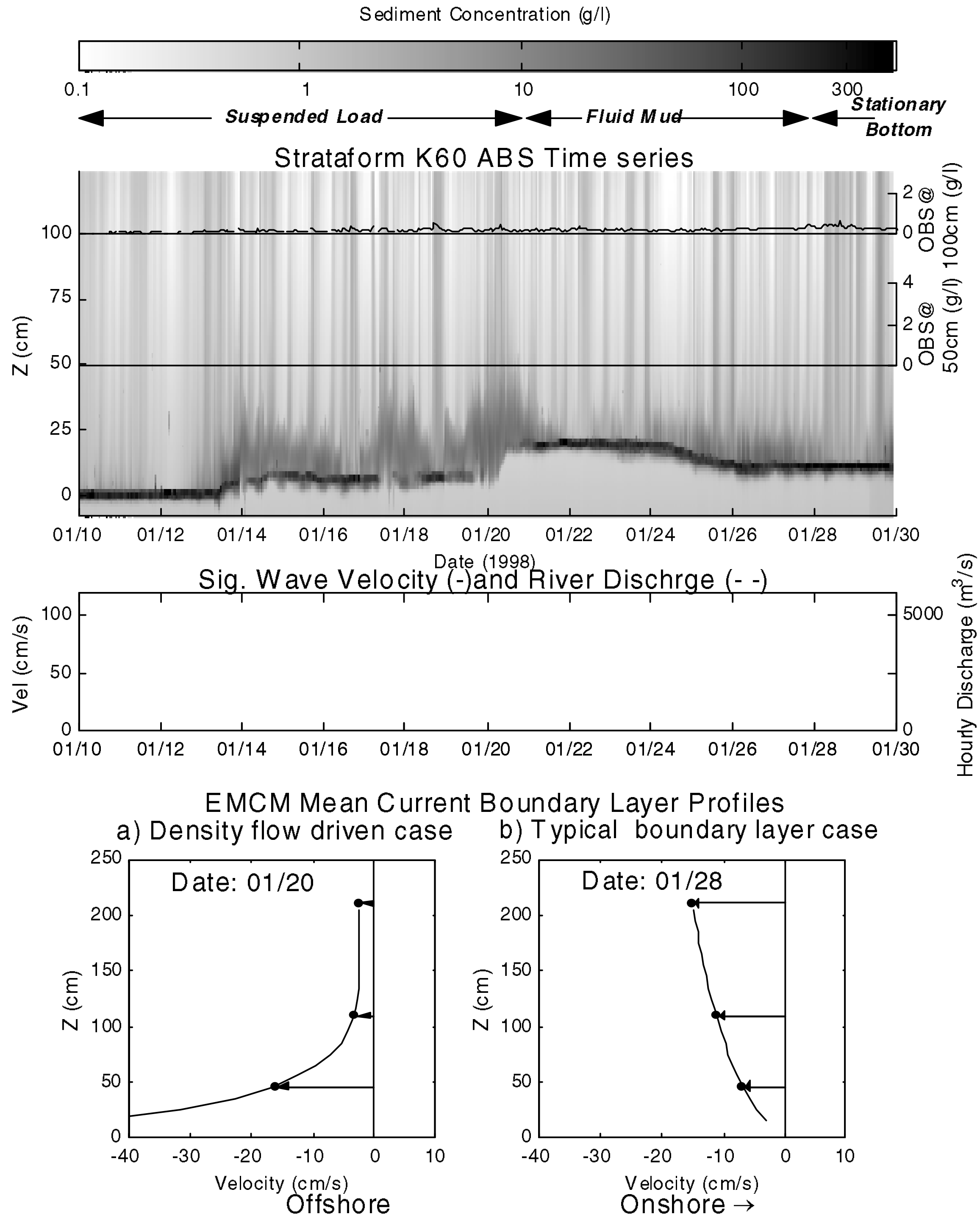

Figure 2. ABS burst averaged data from K60 showing 15 cm thick fluid mud layers on Jan. 14, 17 and 20 correlated with periods of high river discharge and large waves. On Jan 20 EMCM velocity profiles that are indicative of a gravity forced offshore (down-slope) fluid mud transport.